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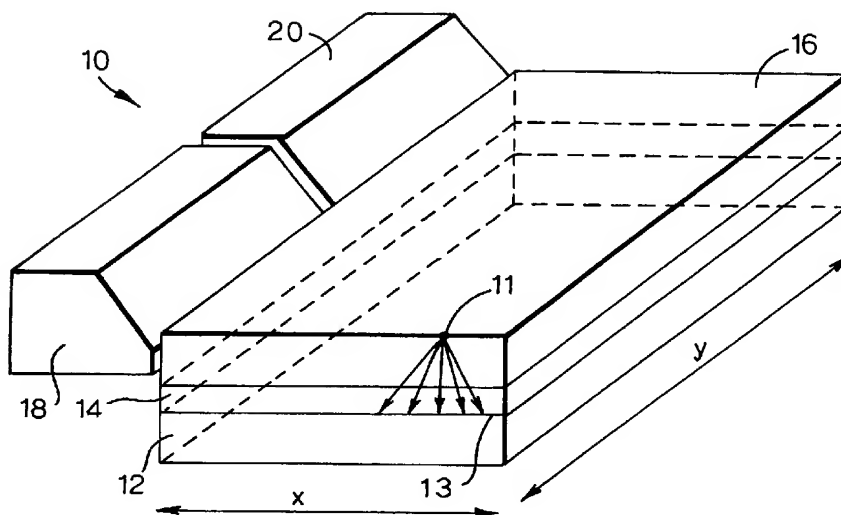
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[Continued on next page]

(54) Title: OPTICAL BIOMETRIC SENSOR WITH PLANAR WAVEGUIDE



(57) Abstract: A biometric sensor (10) comprises a detector array (12) and a planar slab waveguide (16). Diode laser arrays (18, 20) are arranged to couple light into the planar slab waveguide. A ridge of an individual's fingerprint or palmprint, when in contact with the planar slab waveguide at a point of contact therewith, causes a fraction of the light within the waveguide to become unguided at the point of contact, said fraction being detected by the detector array. The sensor has reduced complexity compared to similar sensors employing fibre-optic faceplates and also provides for removal of noise in fingerprint images formed by the sensor, said noise arising from accumulation of dirt or grease on the sensor.



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OPTICAL BIOMETRIC SENSOR WITH PLANAR WAVEGUIDE

This invention relates to biometric sensors.

5 Biometrics is the field of technology concerned with authenticating individuals' identities using one or more personal physical attributes such as fingerprints, iris structure/colour, voice patterns and signature. Biometric systems which record and match fingerprints to establish an individual's identity are well-known. Any such system comprises a fingerprint sensor for forming a
10 representation of an individual's fingerprint and processing means for matching that representation to one or more reference representations of fingerprints.

Fingerprint sensors used in such systems employ a variety of technologies to form a representation of an individual's fingerprint. For example in digital
15 optical sensors, an image of an individual's fingerprint is formed on a charge coupled device (CCD), the output of which is digitised. Such sensors are comparatively bulky and complex. In capacitive silicon sensors, the capacitance between an individual's finger and a silicon platen as a function of position in the plane of the platen is used to generate a representation of an individual's
20 fingerprint. Generally, the ridges of an individual's fingerprint will give rise to higher capacitance than the valleys thereof. Another type of fingerprint sensor utilises ultrasound imaging technology; such sensors provide accurate fingerprint representations but are bulky and expensive. Thermal fingerprint sensors operate by detecting temperature differences between ridges and
25 valleys in an individual's fingerprint when in contact with a flat surface.

Another type of fingerprint sensor operates by detecting pressure differences across a fingerprint when an individual places his finger on the sensor, such differences corresponding to ridges and valleys in the individual's fingerprint.
30 One such sensor incorporates a light-emitting phosphor layer. Ridges of a fingerprint apply a higher pressure to the sensor than do valleys of the fingerprint. In those regions corresponding to fingerprint ridges, increased pressure allows weak electrical currents to pass through the light-emitting

phosphor layer generating light which is detected by a detector array, thus forming a fingerprint image.

5 A particular sub-set of fingerprint sensors, known as a direct optical sensors, provides sensors in which photons emitted at points of contact between an individual's finger and a sensor (i.e. at the ridges of an individual's fingerprint) are detected directly by a detector array in order to form a representation of an individual's fingerprint. This direct optical sensing precludes the need for imaging apparatus within the sensor.

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One such direct optical sensor is described in international patent application PCT/EP00/03849 (international publication number WO 00/70547). This sensor comprises a CMOS detector array or CCD and a fibre-optic faceplate. The fibre-optic faceplate comprises an array of short optical fibres arranged
15 perpendicularly to the plane of the CMOS detector array. In use, an individual places his finger onto the faceplate and residual light emitted at points of contact between the individual and the sensor, i.e. at the ridges of the individual's fingerprint, is guided by optical fibres immediately under the ridges of the individual's finger and directed to the CMOS detector array or CCD at
20 which an image of the individual's fingerprint is formed.

One problem with this sensor is that the requirement for a fibre-optic faceplate adds significantly to the cost and complexity of the sensor. Another problem with this sensor is that representations of fingerprints formed by it are
25 susceptible to noise produced by accumulated dirt and grease on the fibre-optic faceplate.

It is an object of the invention to overcome or ameliorate the aforementioned problems.

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According to a first aspect of the present invention, this object is achieved by a biometric sensor according to the pre-characterising portion of claim 1, characterised in that the radiation directing means comprises a planar slab

waveguide having a core layer with a region which is at least partly exposed and means for introducing radiation into the core layer such that radiation propagates in the exposed region thereof.

- 5 Preferably, the sensor further comprises an interference filter disposed between the planar slab waveguide and the detecting means. This improves the resolving power of the sensor.

- 10 Preferably, the means for introducing radiation into the core layer of the planar slab waveguide comprises one or more diode lasers or light-emitting diodes. This allows intensity of light within the waveguide to be adjusted, enabling images formed by the sensor to be optimised.

- 15 According to a second aspect of the invention, there is provided an electronic apparatus comprising sensor of the invention. Use of such an apparatus may be restricted to one or more individuals having a fingerprint a representation of which is stored in the apparatus, thus precluding the need for a legitimate user of the apparatus to remember a personal identification number.

- 20 According to third aspect of the invention there is provided a method of forming a representation of an individual's fingerprint or palmprint comprising the step of directing radiation from one or more points of contact of the individual with the core of an optical waveguide towards a detector, characterised in that the radiation is so directed by the step of placing the individual's finger in contact
25 with the core of a planar slab waveguide so as to cause radiation initially guided therein to be diverted out of the core and towards the detector.

Embodiments of the invention are described below by way of example only and with reference to the accompanying drawings in which:

30

Figures 1 and 2 show perspective views of biometric sensors of the invention.

Referring to Figure 1, a biometric sensor of the invention is indicated generally by 10. The sensor 10 comprises the following elements disposed together in the following order: a CMOS detector array 12, a transparent layer of polymer or glass 14, and a glass waveguide layer 16. Each of the elements has a width x of 15mm and a length y of 20mm. These dimensions are not critical and may be varied in alternative embodiments of the invention. The CMOS detector array 12 comprises an array of 240 x 360 pixels and may be a standard, commercially available device. The polymer or glass layer 14 has a thickness of approximately 0.1 mm and the glass waveguide layer 16 has a thickness of approximately 0.5 mm, although these dimensions are not critical. The layer 14 acts as a protective layer for the CMOS detector array 12, and should be sufficiently thick to ensure multi-mode waveguiding.

The sensor 10 further comprises two diode-laser arrays 18, 20 each having an emitting facet 10mm wide which is positioned adjacent one edge of the glass waveguide 16. Light emitted by the diode laser arrays 18, 20 is guided throughout the volume of the glass waveguide 16.

In use of the sensor 10, an individual's finger is placed on the exposed surface of the glass waveguide layer 16. At those positions, such as 11, where a fingerprint ridge of the individual makes contact with the glass waveguide 16, a proportion of light within the waveguide 16 ceases to be guided therein and passes out of the waveguide 16 and through the layer 14 and is detected at the detector array 12. An image of the individual's fingerprint is thus formed on the detector array 12.

Referring now to Figure 2, another sensor of the invention is indicated generally by 50. The sensor 50 has a similar construction to that of the sensor 10, and comprises a CMOS detector array 52, a layer 54, an interference filter 55, a glass waveguide 56 and diode laser arrays 58, 60. In use of the sensor 50, an individual's finger is placed on the exposed surface of the glass waveguide layer 56. At positions, such as 51, where a fingerprint ridge of the individual makes contact with the glass waveguide 56, a proportion of light within the waveguide

56 ceases to be guided therein and passes out of the waveguide 56 and through the layer 54 and interference filter 55, and is detected at the CMOS detector array 52. An image of the individual's fingerprint is thus formed on the CMOS detector array 52.

5.

The interference filter 55 operates to reduce the solid angle of diverted light subtended by the CMOS detector array 52 at the point at which the individual's fingerprint ridge makes contact with the waveguide 56. This provides the sensor 50 with a greater resolution than that of the sensor 10.

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Sensors of the invention are principally intended to image an individual's fingerprint, however they are also suitable for examining other, similar, physical characteristics of an individual, for example palm prints.

15 An alternative sensor of the invention comprises a waveguide formed from a transparent material other than glass, for example a transparent polymer.

In further alternative sensors of the invention, light may be introduced into, and distributed within, the waveguide of a sensor of the invention by other means.

20 For example, a sensor of the invention may comprise a plurality of light-emitting diodes disposed along the edges of the sensor's waveguide. Alternatively, reflective coatings may be applied to edges of a sensor's waveguide, and light from a laser diode arranged to undergo multiple reflections within the waveguide to provide substantially uniform illumination therein.

25

Referring again to Figure 1, grease or dirt collecting on the exposed surface of the waveguide 18 results in noise in images of fingerprints formed by the sensor 10. Such noise may be recorded by increasing the intensity of light within the waveguide 18 so as to form a clear image of the grease or dirt on the CMOS detector array 12. The intensity of light within the waveguide is increased by increasing the current supplied to the diode laser arrays 20, 22. The image of the grease or dirt may then be subtracted from a fingerprint image to eliminate

30

noise therefrom. Image recording and subtraction are performed by image recording and processing means (not shown).

5 A sensor of the invention may be incorporated into an apparatus, particularly an electronic apparatus such as a mobile telephone, the use of which is required to be restricted to one or more individuals. Such an apparatus further comprises means for storing one or more representations of fingerprints and means for comparing stored representations of fingerprints with representations generated by the sensor. Such an apparatus avoids the need for a legitimate user of the
10 apparatus to remember and enter a personal identification number in order to use the apparatus. Rather, a user is authenticated by his fingerprint.

CLAIMS

1. A direct optical biometric sensor (10; 50) comprising detecting means (12; 52) for detecting radiation and radiation directing means (18, 20, 16; 58, 60, 56) for directing radiation from a point of contact (11; 51) of an individual with the radiation directing means towards the detecting means in response to contact of the individual with the radiation directing means at the point of contact, characterised in that the radiation directing means comprises a planar slab waveguide (16; 56) having a core layer with a region which is at least partly exposed and means (18, 20; 58, 60) for introducing radiation into the core layer such that radiation propagates throughout the exposed region thereof.
2. A sensor according to claim 1 wherein the sensor further comprises an interference filter (55) disposed between the planar slab waveguide and the detecting means.
3. A sensor according to claim 1 or claim 2 wherein the means for introducing radiation into the core layer of the planar slab waveguide comprises one or more diode lasers (18, 20; 58, 60) or light-emitting diodes.
4. A biometric sensor substantially as hereinbefore described with reference to Figure 1.
5. A biometric sensor substantially as hereinbefore described with reference to Figure 2.
6. An electronic apparatus comprising a sensor according to any preceding claim.
7. A method of forming a representation of an individual's fingerprint or palmprint comprising the step of directing radiation from one or more points of contact of the individual with the core of an optical waveguide towards a

detector, characterised in that the radiation is so directed by the step of placing the individual's finger in contact with the core of a planar slab waveguide so as to cause radiation initially guided therein to be diverted out of the core and towards the detector.

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Fig.1.

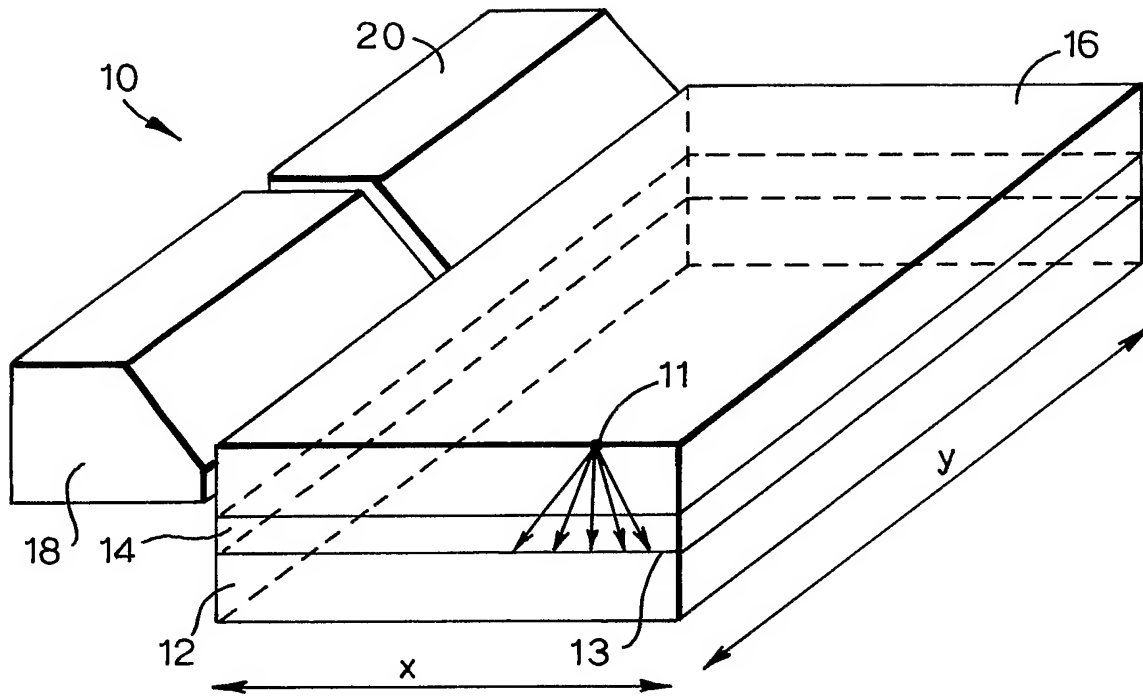
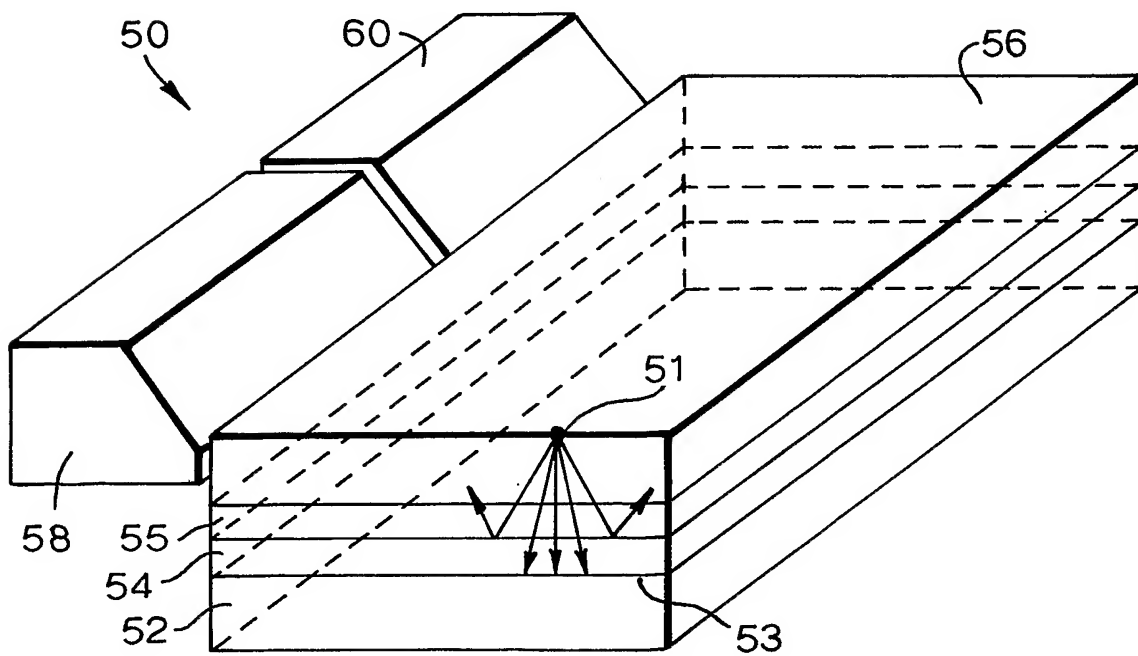


Fig.2.



INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 G06K9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FUJIEDA I ET AL: "FINGERPRINT INPUT BASED ON SCATTERED-LIGHT DETECTION" APPLIED OPTICS, OPTICAL SOCIETY OF AMERICA, WASHINGTON, US, vol. 36, no. 35, 10 December 1997 (1997-12-10), pages 9152-9156, XP000828205 ISSN: 0003-6935	1-3, 6, 7
Y	The whole document, in particular section 2 with figure 2 --- -/--	4, 5

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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- *A* document defining the general state of the art which is not considered to be of particular relevance
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- *P* document published prior to the international filing date but later than the priority date claimed

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- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- * & * document member of the same patent family

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INTERNATIONAL SEARCH REPORT

International Application No

PC 1/GB 03/00042

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DRAKE M D ET AL: "WAVEGUIDE HOLOGRAM FINGERPRINT ENTRY DEVICE" OPTICAL ENGINEERING, SOC. OF PHOTO-OPTICAL INSTRUMENTATION ENGINEERS. BELLINGHAM, US, vol. 35, no. 9, 1 September 1996 (1996-09-01), pages 2499-2505, XP000633939 ISSN: 0091-3286 Section 2 with figure 5 ---	1-3,6,7
Y	WO 01 18741 A (DIGITAL PERSONA INC; BROWNLEE KENNETH (US); IVANISOV ALEXANDER (US)) 15 March 2001 (2001-03-15) page 5, line 1-20; figures 4,5 -----	4,5

INTERNATIONAL SEARCH REPORT

nation on patent family members

International Application No

PCT/GB 03/00042

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